Expert Systems for Marine Oil Spill Response Operations

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Abstract

This presentation assesses the potential for 'expert systems' as one way of reducing the threat of marine oil spills in the Georgia Basin/Puget Sound region. Over 15 billion gallons of oil moved in and out of the area in 2000.

Expert systems in effect transfer the knowledge of an expert to a computer. Over 15,000 of them have been developed so far. Their general features, strengths and limitations are examined first, along with examples of their application. There follows an assessment of their worldwide application to oil spills, and the prospects for their further development.

Expert systems can save precious time in the event of a catastrophic spill, but can be complicated and costly to develop. Simple decision support tools can, however, be designed that are both cost-effective and practical.

Oil spill recovery techniques have basically stagnated for thirty years—typically, only 5 to 15 percent of oil spilled on the water will be recovered. Information technology offers some hope of improving that record by speeding up decision-making and potentially preventing costly environmental damage. Consideration should therefore be given to supporting innovative R&D in the Georgia Strait/Puget Sound basin into expert systems, as an innovative approach to problem-solving and emergency management.

Introduction

This paper examines the use of expert systems with respect to offshore oil spills. The paper commences with a look at expert systems in general, how they work and who uses them. This is followed by an examination of their perceived strengths and weaknesses, as well as their existing and potential applications to marine oil spill response operations.

What are Expert Systems?

Expert systems are computer software programs that capture the knowledge of an expert or experts in a particular field or fields. The experts are usually referred to as 'domain experts.' The computer professionals who capture this knowledge in a database are referred to as 'knowledge engineers.' For their part, the software programs include a set of 'rules' that are deemed by the experts to govern the field in question. These rules are laid down based on the experience of the expert from past events. Typically, expert systems also include an 'inference engine,' which is the method for deciding which rules are to apply in the present situation.

Expert systems are a type of decision-support system, i.e. they are intended to assist people who have to make decisions. They are often based on an 'if/then hypothesis.' In other words, the computer determines that if one or more conditions are present, then one or more action points are called for, based on previous experience in similar circumstances.

Expert systems sometimes arrive at a conclusion or recommendation via the process of elimination. In other words, they scour the database and eliminate every possibility but one, that last possibility being the one most likely to apply in this situation. The kind of advice an expert system can give a decision-taker can take many different forms. Thus, it could recommend a particular course of action, e.g. "Do this!". Conversely, it could recommend against a particular course of action, e.g. "Don't do this!".

Some Common Applications of Expert Systems

Expert systems are commonly used in emergency response in general (of which marine oil spill response operations are a subset) (Slap et al. 2002). They are also applied for troubleshooting. Thus, if you have ever had trouble with your computer printer, then chances are you have used an expert system (whether you knew it or not). Auto mechanics also use expert systems to find out what is wrong with a car that needs fixing. Similarly, expert systems are frequently used in the medical field, particularly with respect to interpreting laboratory results.

In short, expert systems have a broad application in many different fields, and are used by experts and non-experts alike. As the title of Larry Smith's book – *Beyond The Internet: How Expert Systems Will Truly Transform Business* would suggest, expert systems are predicted by some at least to have a brilliant future (Smith 2001).

Expert Systems: A Love/Hate Relationship

Not everyone loves expert systems; some people think they are wonderful, while others distrust them. Often, though, people have mixed opinions about them. In other words, even those who like them don't think they're perfect, and those who distrust them admit that can be useful in some cases. This is only natural, especially with a relatively new technology.

Expert systems in general have many potentially positive features. In contrast to a human expert, who can only work a certain number of hours before his or her performance falls off, an expert system is available 24 hours per day, seven days per week, 365 days of the year. Plus, an expert system doesn't charge overtime!

Moreover, whereas a human expert can only be in one place at a time, and can only deal with x number of people simultaneously, an expert system is available to multiple users at the same time, no matter where they happen to be. Thus, one user could be in Timbuktu and another in Tahiti, whereas the actual system could be accessible via the Internet from a server in Tacoma, or from a CD-ROM.

While it is true that expert systems can take a certain amount of time to process information keyed in to it to arrive at a recommended course of action, a general feature is that they can speed up decision-making. This is particularly true when they are used to sort out complicated situations, involving a significant amount of data or calculations.

They can also make the decision-making process transparent. An example of this would be where a responder is asked to justify the choice of a certain course of action to his superior, whether before or after a decision has been made. He or she can point to a screen, or print something out which outlines the reasoning behind a decision, indicating that this was the best available course of action, as determined by experts who have been confronted with similar situations in the past. At the same time, expert systems may be thought of as providing accountability. Thus, that same responder could be asked to explain why he or she chose a certain course of action that ran counter to the recommendation of the expert system.

Another feature of expert systems is that they can 'nudge' a decision-maker to consider certain elements in the course of making a decision, things that might not be considered otherwise.

On the negative side, some people just don't like computers, especially if they are working in the field and have to make decisions on the fly. For these people, computers are just a nuisance, a gadget whose batteries will run out, or an expensive toy on which coffee will get spilled.

Another limitation of these systems is that some expertise simply cannot be automated. This is proof enough that expert systems are no substitute for human judgment. It is, in fact, a common misunderstanding that expert systems are meant to replace the judgment of humans. More often than not, such systems will simply remind an expert what he or she knows already, but has forgotten, perhaps in the 'heat of battle.'

How Marine Oil Spill Response Lends Itself to Expert Systems (and Vice Versa)

If ever there were an area ripe for high-tech innovation, it would have to be marine oil spill response operations. For this is a field that has not appreciably evolved in the past 30 years—this in spite of vast sums of money being dedicated to research and development (Ornitz and Champ 2001).

Looking at historical 'encounter rates' for oil, i.e. the amount of oil recovered from a marine spill, one is lucky if greater than five or ten percent of the oil spilled on the water is ever picked up from the water or shoreline. This low success rate is principally due to the inherent limitations of so-called mechanical recovery techniques, consisting mainly in the use of booms and skimmers (often used in tandem).

Spill response is normally a complex, multi-disciplinary affair; on all but the simplest of spills, few people can be expected to possess all of the specialist knowledge required to mount an effective response operation. Moreover, each spill will require its own specific skill sets, some of which will not necessarily be on hand when they are needed.

Similarly to firefighting, speed is a key ingredient in successful oil spill response; the sooner one can stop oil from leaking out of a vessel, or from spreading on the ocean, the less the environmental damage is likely to be. Naturally, if the spill can be quickly contained, cleanup costs should also be kept to a minimum. All the more reason, then, to invest in expert systems if it can be shown that they are cost-effective. Similarly, the relationship between time and cost makes it all the more important to 'get it right the first time', choosing the right combination of response options, for to do otherwise is to waste precious time (and money). Even gaining an hour on a spreading oil slick could save millions of dollars in cleanup and/or compensation costs.

Major spills also have the habit of occurring only every four or five years. This trend has several implications. First, a major spill may occur anywhere on the world's ocean; this tends to make planning difficult. Second, the relative infrequency of spills means that the people who fought the last big one may not be available for the present one—people tend to move on, or retire, or even to forget how the last one was fought. Manuals exist, of course, but they tend to be very general, and the information and/or advice they provide may or may not be applicable to the specific crisis one is confronted with at this moment. Now, it can be argued that since no two spills are alike, it is impossible to generalize about spills, which would of course severely limit the effectiveness of expert systems. Nevertheless, it is generally agreed amongst the spill response experts themselves that we need to 'learn the lessons of history' (Salt 2002), and to document certain 'rules of thumb.' (Owens 1999)

Lastly, one must recognize that, in times of crisis, even an expert can fumble and make mistakes. An expert system can act as a reminder to the responder, or it can offer a second opinion. The responder is not bound by such advice, but it could prove useful to him or her in the heat of battle.

Aspects of Spill Response to Which Expert Systems Could be Applied

While expert systems could no doubt be applied to virtually any aspect of spill response, this paper concentrates on a total of seven types of response activities. Each will be examined in turn.

1. **Containing and recovering spilled oil at sea**
   An expert system could tell you whether booms and skimmers will work, given the sea state, for instance. Such mechanical devices are notorious for performing beautifully on paper, but for falling fall short of specifications in real-time situations, when the winds may be howling and the waves breaking over the boom. Thus, an expert system could save a lot of time if it could tell you in advance that it is a waste of time deploying these devices; you could instead move on to some other response option that stands a better chance of working, under the circumstances. The system could also be designed to tell you the most appropriate model of a certain type of equipment to use, and even how to deploy it. At its simplest, the responder could merely be directed to a site where more information could be obtained.

2. **Protection of sensitive shoreline**
   Here an expert system could be developed to determine any number of things, such as: where to deploy so-called 'deflective' boom; the specific type of boom to use; how much will be needed; where to get it; how to deploy it, and what to do if it doesn't work.

3. **Beach cleanup**
   Examples of how an expert system could help with respect to beach clean up would include the selection of the most appropriate cleanup method, such as rakes or shovels, based on the beach type, type of oil, etc. It could also tell you whether a beach had potential as a 'sacrificial' beach, i.e. whether spilled oil could be directed onto it for collection, recycling or disposal.

4. ***In situ* burning of the oil**
   If the controversial response option of burning the oil at sea were being contemplated, an expert system could perhaps perform a Net Environmental Benefit Analysis (NEBA) to determine if the benefits outweighed the risks. Some factors that might be considered include: the type of oil (some types don't burn); the distance from shore of the oil to be burned; the wind direction; the proximity of communities downwind, and the 'weathered' state of the oil (oil will not burn, for instance, once its water content reaches a certain level). Or, the system could simply advise you to consult "Joe Blow" before deciding.

5. **Use of dispersants from the air or from a vessel**
   This is another controversial response option, particularly in North America. Were the use of dispersants to be sanctioned, an expert system could, for example, warn you not to use this option unless the spilled oil were a certain distance from shore, or nowhere near shellfish beds. It could also tell you whether dispersants are going to work at all on the type of oil in question. Finally, the system could tell you which is the most appropriate dispersant to use, based on the oil type, the sea state, environmental conditions, etc.

6. **Disposal of oil/oily debris**
   Getting rid of oily waste that has been cleaned up tends to be one of the trickiest aspects of marine oil spill response. For one thing, it is often difficult to temporarily store the recovered oil in a vessel at sea; the problem can be complicated by the fact that skimmers often suck up a large quantity of water along with the oil. Thus, an expert system might remind a responder that if, for example, one thousand barrels of heavy fuel oil has been collected off the water's surface, then seven times that will be needed in terms of storage capacity. Similarly, the system could recommend decanting the water from the oil before going on to recycle the oil.

   An expert system could also advise responders to practice triage of the various waste streams on the beach, e.g. oil, wood, soiled clothing, etc., before hauling them off to the appropriate destination for recycling, incineration, landfilling, etc.

7. **Deciding on 'best response'**
   Beyond proffering advice *vis a vis* individual response options, an expert system could be developed to determine the optimal combination of response options, taking account of such elements as: weather conditions; type, volume and location of the oil spilled; the anticipated trajectory of the spilled oil; sensitive environments in the path of the oil; available equipment, personnel and other resources. Admittedly, software programs already exist to calculate many of these elements; however, an expert system might go one step further by bringing them all together and making one big calculation.

Other Potential Applications of Expert Systems

In addition to being useful in an operational setting, expert systems could be used for several other purposes. For example, they could serve as a planning tool, to indicate, for instance, the risks or implications of adopting a particular response option or strategy. Similarly, an expert system could be used to predict the likelihood of a particular course of action being successful.

Expert systems could also be used to train marine oil spill responders, or indeed anyone connected with marine spill response operations.

Conclusion

By way of summary, expert systems represent a widely used, proven technology. They are particularly useful where timing is crucial, and decision-making is complex.

There would appear to be a significant, largely untapped potential for the application of expert systems to marine oil spill response operations, where lessons have been learned from responding to hundreds of major spills over the course of the past 30 years or so. We have to get away from the bad habit of treating virtually every offshore oil spill as if it were the first one.

A quicker, more decisive response—one made possible by an expert system, could save industry and governments precious time and significant amounts of money at the time of a disaster. In short, expert systems could be a potent, cost-effective weapon in the arsenal of response tools. For this reason, a joint industry-government Georgia Basin/Puget Sound expert system research and development program for oil spill response would appear to be warranted.

For more detailed background information regarding expert systems, readers are directed to the web site of Acquired Intelligence, Inc. (www.aiinc.ca), a Victoria-based company that develops them for clients around the world. AI's site includes several demo expert systems. Worldocean Consulting Ltd and AI are jointly developing expert systems for application to marine oil spill response operations.

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